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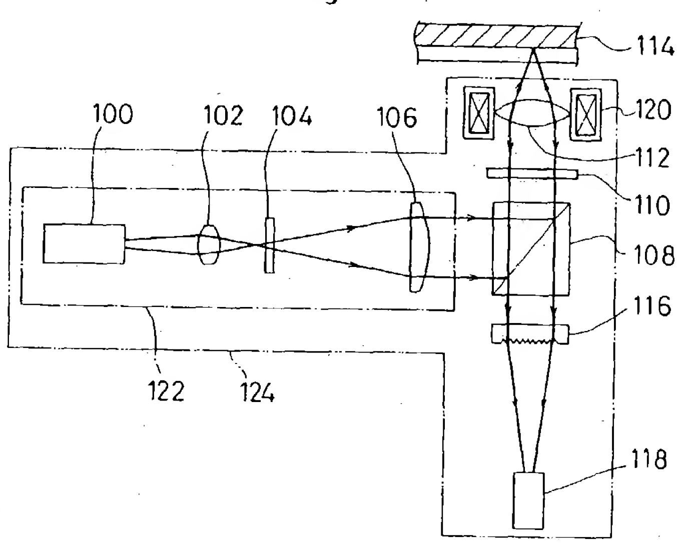
(54) **Superresolution scanning optical device.**

(57) A superresolution scanning optical device has image forming means for forming the image of light from a coherent light source unit (122) in the form of a fine spot on a conjugate face through an image forming optical system, and scanning means for scanning the fine spot formed on the conjugate face. The coherent light source unit (122) has first and second light sources of which phases are reverse to each other. The first and second light sources have the relationship that the main lobe of the image of the second light source on the conjugate face is superposed on the lateral sides of the main lobe of the image of the first light source on the conjugate face.

Fig.1



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In view of the foregoing, the present invention is proposed with the object of providing a simple optical system capable of obtaining superresolution smaller than of the diffraction limit without the amount of light in the main lobe remarkably decreased.

[Summary of the Invention]

A first superresolution scanning optical device according to the present invention comprises image forming means for forming the image of light from a coherent light source unit in the form of a fine spot on a conjugate face through an image forming optical system, and scanning means for scanning the fine spot formed on the conjugate face, the coherent light source unit having at least first and second light sources of which phases are reverse to each other, the first and second light sources having the relationship that the main lobe of the image of the second light source on the conjugate face is superposed on the lateral sides of the main lobe of the image of the first light source on the conjugate face.

Accordingly, the amplitudes of the lateral sides of the main lobe of the image of the first light source are cancelled by the amplitude of the main lobe of the image of the second light source, thus reducing the width of the main lobe of the image of the first light source. It is therefore possible to obtain superresolution smaller than the diffraction limit without slit-like or annular openings formed. Thus, with a simple optical system, superresolution can be achieved without the amount of light of the main lobe remarkably decreased.

In the first superresolution scanning optical device, the coherent light source unit may further include a third light source presenting the same phase as that of the first light source, and the second and third light sources may have the relationship that the main lobe of the image of the third light source on the conjugate face is superposed on the lateral sides of the main lobe of the image of the second light source on the conjugate face. In such an arrangement, that remaining portion of the reverse phase component of the image of the second light source which has not been cancelled in the interference of the phase component of the image of the first light source with the reverse phase component of the image of the second light source, is cancelled by the regular phase component of the image of the third light source. This reduces the amplitudes of the sub-lobes of the intensity distribution formed by the interference of the image of the first light source with the image of the second light source.

A first superresolution light source device for optical device according to the present invention comprises at least first and second light sources which are coherent with each other and which are reverse in phase, the first light source being disposed on the optical axis of an image forming optical system or in the vicinity of this optical axis, and the second light source being disposed in the vicinity of the first light source.

Accordingly, the amplitudes of the lateral sides of the main lobe of the image of the first light source are cancelled by the amplitude of the main lobe of the image of the second light source. This reduces the width of the main lobe of the image of the first light source. It is therefore possible to obtain superresolution smaller than the diffraction limit without slit-like or annular openings for restraining the side lobes formed. Thus, superresolution can be achieved without the amount of light of the main lobe decreased.

In the first superresolution light source device for optical device above-mentioned, provision may be made such that the second light source is smaller in output than the first light source. In such an arrangement, there may be reduced the amplitude of that remaining portion of the reverse phase component of the image of the second light source which has not been cancelled in the interference of the phase component of the image of the first light source with the reverse phase component of the image of the second light source. This may reduce the amplitudes of the sub-lobes of the intensity distribution formed by the interference of the image of the first light source with the image of the second light source.

The first superresolution light source device for optical device above-mentioned may further comprise a third light source which is coherent with the second light source and which has a phase reverse to that of the second light source, the third light source being located in the vicinity of and at the opposite side of the second light source with respect to the first light source. In such an arrangement, there may be reduced the amplitude of the sub-lobes of the remaining portion of the intensity distribution which has not been cancelled in the interference of the image of the first light source with the image of the second light source.

In the first superresolution light source device for optical device above-mentioned, provision may be made such that the second light source is smaller in output than the first light source, and that the third light source is smaller in output than the second light source. This may further reduce the amplitudes of the sub-lobes of the intensity distribution formed by the interference of the images of the first and second light sources with each other.

A second superresolution light source device for optical device comprises a coherent light

superresolution equivalent to that obtained by the first superresolution light source device for optical device having the first and second light sources mentioned earlier.

A second superresolution filter for optical device in accordance with the present invention comprises a holographic optical element which has a hologram recorded on the surface thereof, the hologram presenting the waves of phase row light sources including first and second light sources from which lights are emitted in the form of waves of which phases are reverse to each other, and a third light source presenting a phase reverse to that of the second light source, the hologram being arranged such that, when diffracted light from the hologram is focused, a main lobe formed by the second light source is superposed on the lateral sides of a main lobe formed by the first light source, and a main lobe formed by the third light source is superposed on the lateral sides of a main lobe formed by the second light source.

Accordingly, inspite of the use of a single point light source, there can be holographically achieved superresolution equivalent to that obtained by the first superresolution light source device for optical device having the first, second and third light sources mentioned earlier.

A third superresolution filter for optical device comprises a holographic optical element which has a computer-synthesized hologram recorded on the surface thereof, the computer-synthesized hologram presenting the waves of phase row light sources including first and second light sources from which lights are emitted in the form of waves of which phases are reverse to each other, the waves being calculated as an inline-type Fourier transform hologram, the computer-synthesized hologram being arranged such that, when diffracted light from the hologram is focused, a main lobe formed by the second light source is superposed on the lateral sides of a main lobe formed by the first light source.

Accordingly, inspite of the use of a single point light source, there can be achieved, by the computer-synthesized hologram, superresolution equivalent to that obtained by the first superresolution light source device for optical device having the first and second light sources mentioned earlier.

A fourth superresolution filter for optical device according to the present invention comprises a holographic optical element which has a computer-synthesized hologram recorded on the surface thereof, the hologram presenting the waves of phase row light sources including first and second light sources from which lights are emitted in the form of waves of which phases are reverse to each other, and a third light source presenting a phase reverse to that of the second light source, the waves being calculated as an inline-type Fourier transform hologram, the computer-synthesized hologram being arranged such that, when diffracted light from the hologram is focused, a main lobe formed by the second light source is superposed on the lateral sides of a main lobe formed by the first light source, and a main lobe formed by the third light source is superposed on the lateral sides of a main lobe formed by the second light source.

Accordingly, inspite of the use of a single point light source, there can be achieved, by the computer-synthesized hologram, superresolution equivalent to that obtained by the first superresolution light source device for optical device having the first, second and third light sources mentioned earlier.

A second superresolution scanning optical device comprises a coherent light source, focusing means having a collimate lens for focusing a coherent beam emitted from the coherent light source on a recording surface of an optical disc, and control means for controlling the relative position of the focusing means with respect to the recording surface of the optical disc, the collimate lens having, in a unitary structure, any of the first to fourth superresolution filters for optical device above-mentioned.

Accordingly, with the use of a single point light source, there can be readily obtained a superresolution scanning optical device by which the amount of light of the main lobe of the light source image is not remarkably reduced.

A third superresolution scanning optical device according to the present invention comprises a coherent light source, focusing means having an objective lens for focusing a coherent beam emitted from the coherent light source on a recording surface of an optical disc, and control means for controlling the relative position of the focusing means with respect to the recording surface of the optical disc, the objective lens having, in a unitary structure, any of the first to fourth superresolution filters for optical device above-mentioned.

Accordingly, with the use of a single point light source, there can be readily obtained a superresolution scanning optical device by which the amount of light of the main lobe of the light source image is not remarkably reduced.

A fourth superresolution scanning optical device according to the present invention comprises a coherent light source and focusing means having a collimate lens, a polygon mirror and a focusing lens for focusing a coherent beam emitted from the coherent light source, the collimate lens having, in a unitary structure, any of the first to fourth superresolution filters for optical device above-mentioned.

which (a) is a front view thereof and (b) is a section view taken along the line XVII-XVII in Figure 17 (a);

Figure 18 is a schematic view of the arrangement of a laser beam printer device to which the holographic filter for superresolution above-mentioned is applied;

Figure 19 is a schematic view illustrating the arrangement of an optical pickup head system in a conventional superresolution scanning optical device; and

Figure 20 is a view illustrating the principle of superresolution by the optical pickup head system in the conventional superresolution scanning optical device.

[Detailed Description of the Invention]

Fig. 1 schematically shows the arrangement of an optical pickup head system in a superresolution scanning optical device in accordance with a first embodiment of the present invention.

As shown in Fig. 1, light emitted from a coherent light source 100 such as a semiconductor laser, is focused on a phase plate 104 by a focusing lens 102, and then passes a collimate lens 106. Then, the light is reflected by a polarized beam splitter 108 and passed through a quarter wave plate 110, and is guided to an objective lens 112 and reaches an optical disc 114, where the image of the light is formed on a pit face thereof. In a returning path, the light which has passed through the objective lens 112, the quarter wave plate 110 and the polarized beam splitter 108, impinges into a servo signal detecting holographic optical element (See Japanese Patent Laid-Open Publication No. 1-92541, Japanese Patent Laid-Open Publication No. 1-94542 and USP 4,929,823) 116 which achieves a spot size detection (SSD) method and a push-pull method for detecting a focusing signal and a tracking signal. Then, the light reaches a photodetector 118. In Fig. 1, an actuator 120 is disposed for driving the objective lens 112.

The coherent light source 100, the focusing lens 102, the phase plate 104 and the collimate lens 106 which have been discussed above, form a superresolution light source device 122. The superresolution light source device 122, the polarized beam splitter 108, the quarter wave plate 110, the objective lens 112, the servo signal detecting holographic optical element 116 and the photodetector 118 form a light pickup head device 124.

Fig. 2 (a) shows the arrangement in front elevation of the phase plate 104, while Fig. 2 (b) shows the arrangement thereof in section taken along the line II-II in Fig. 2 (a). Fig. 3 shows the state of a beam waist 126 (waist diameter: w) in the vicinity of the phase plate 104.

The phase plate 104 has an annular phase structure. The phase plate 104 is provided on the surface thereof with a center zone 104a which comprises a circular convex and which serves as a first phase area, an intermediate zone 104b which comprises an annular concave formed outside of the center zone 104a and which serves as a second phase area, and an outer zone 104c which comprises an annular convex formed outside of the intermediate zone 104b and which serves as a third phase area. An opaque layer 104d is formed outside of the outer zone 104c on the surface of the phase plate 104. The center zone 104a and the outer zone 104c have the same height. Formed between the intermediate zone 104b and each of the center zone 104a and the outer zone 104c is a difference in level d_1 for generating a phase difference π between transmitted lights each having a wavelength λ. This difference in level d_1 is given by the following equation:

$$d_1 = \lambda/(2 \times (n-1))$$

wherein n is the refractive index of the phase plate 104.

With the arrangement above-mentioned, out of light emitted from the coherent light source 100, a light portion which passes through the intermediate zone 104b and a light portion which passes the center zone 104a, are reverse in phase to each other, while a light portion which transmits the outer zone 104c and a light portion which transmits the intermediate zone 104b, are reverse in phase to each other.

Fig. 4 schematically shows the arrangement of an optical pickup head system in a superresolution scanning optical device in accordance with a second embodiment of the present invention. The basic arrangement of this optical pickup head system is shown by ["Recent advances in optical pickup head with holographic optical elements", M.Kato et al., Proc. SPIE vol. 1507, pp. 4, EGO'91, Holographic Optics III: Principles and Applications, 11-15 March 1991, The Hague, The Netherlands].

As shown in Fig. 4, light emitted from an emission point 200a (an active layer emission face having a slit-like opening formed in a semiconductor laser) of a coherent light source 200, is focused on a reflexion-type phase plate 204 by a condenser lens 202. Then, the light passes a collimate lens 206 and a servo signal detecting holographic optical element 208 similar to that used in the first embodiment. The light is then guided to an objective lens 210 and reaches an optical disc 212, where the image of the light is formed on a pit face thereof. In a returning path, the light which has passed the objective lens 210, the servo signal detecting holographic optical element 208 and the

302a of the second light source 302A). Since the third light source 303A, 303B is located in the vicinity of both sides of the second light source 302A, 302B with the same phase as that of the first light source 301, a double diffraction image (a complex amplitude distribution) 303a of the third light source 303A is coherently superposed in the same manner above-mentioned (a double diffraction image of the third light source 303B is not shown, but is axially symmetric with respect to the double diffraction image 303a of the third light source 303A). The intensity distribution of a spot image obtained as a result of the interference of the first light source 301, the second light source 302A, 302B and the third light source 303A, 303B with one another, shows superresolution as substantially shown by a curve 320.

Referring to Fig. 8, the following description will discuss an example of design of the phase row light sources in each of the first and second embodiments of the present invention, while giving comprehensible numerals by way of example.

First, the following is now set forth as a premise.

The complex amplitude of the double diffraction image of the first light source 301 is represented by

$$u_1(x) = \sin x/x \qquad (1).$$

The complex amplitudes of the double diffraction images of the second light source 302A, 302B are represented by

$$u_{2A}(x) = A_{+1} \times (\sin(x-\delta_1)/(x-\delta_1)) \qquad (2)$$

$$u_{2B}(x) = A_{-1} \times (\sin(x+\delta_1)/(x+\delta_1)) \qquad (3)$$

The complex amplitudes of the double diffraction images of the third light source 303A, 303B are represented by

$$u_{3A}(x) = A_{+2} \times (\sin(x-\delta_2)/(x-\delta_2)) \qquad (4)$$

$$u_{3B}(x) = A_{-2} \times (\sin(x+\delta_2)/(x+\delta_2)) \qquad (5)$$

In the equations above-mentioned, A_{+1}, A_{-1} and A_{+2}, A_{-2} respectively refer to the relative amplitudes of the second light source 302A, 302B and the third light source 303A, 303B when the amplitude of the first light source 301 is normalized to 1. Here, x is equal to $(a/(\lambda \times f)) \times \xi$, a is the opening diameter of the aperture face 312, $\overline{\delta_1}$ is the coordinates of the peak position in the complex amplitude distribution of the second light source 302A, 302B, δ_2 is the coordinates of the peak position in the complex amplitude distribution of the third light source 303A, 303B, is the wavelength of each light source, f is equal to f_2 (f_2 is the focal length of an objective lens 308. See Fig. 7), and ξ is the coordinates of the image forming face 310 in terms of real dimensions. In Fig. 7, f_1 is the focal length of a focusing lens 306.

The complex amplitude distribution of a double diffraction image obtained as a result of the coherent superposition of the equations (1) to (5) is represented by the following equation:

$$\begin{aligned} u(x) = &\sin x/x \\ &+ A_{+1} \times (\sin(x-\delta_1)/(x-\delta_1)) \\ &+ A_{-1} \times (\sin(x+\delta_1)/(x+\delta_1)) \\ &+ A_{+2} \times (\sin(x-\delta_2)/(x-\delta_2)) \\ &+ A_{-2} \times (\sin(x+\delta_2)/(x+\delta_2)) \qquad (6) \end{aligned}$$

In Fig. 8, plotted in the form of a curve 320 is the intensity distribution of the double diffraction image, i.e., $I_1(x) = |\mu(x)|^2$, which is calculated, by way of design example, according to the equation (6) in which $A_{+1} = A_{-1} = -0.3$, $A_{+2} = A_{-2} = 0.15, 3$, $\delta_1 = 2.5$rad and $\delta_2 = 5$rad. For comparison, Fig. 8 also shows, in the form of a curve 330, $I_{00}(x) = 0.73 \times I_0$ which represents a distribution where the peak value I_0 on the optical axis of the intensity distribution of the double diffraction image formed with the first light source 301 alone, is arranged as multiplied by 0.73.

From the results of these calculations, it is understood that the intensity distribution 320 of the double diffraction image is reduced to about 1.1/1.4 (approximately 0.79) in half-width as compared with the distribution 330 above-mentioned (where the distribution obtained with the first light source 301 alone is multiplied by 0.73).

Further, the rate of the amount of light distributed outside of the half-width is reduced as compared with the distribution 330 where the distribution obtained with the first light source 301 alone is multiplied by 0.73. Accordingly, there is eliminated a slit optical system (designated by 26 in Fig. 19) for restraining the side lobes which is used in a conventional superresolution optical system having a simple annular opening.

In a normal image forming optical system, there is generally used a circular aperture rather than a rectangular aperture In this case, the shape of a spot obtained on the image forming plane is expressed by the following equation using the first-kind Bessel's Function $J_1(r)$:

$$u(r) = 2 \times J_1(r) \times (1/r) \qquad (7)$$

wherein r is given by $a \times (1/\lambda f) \times \xi$.

As compared with an arrangement having a rectangular aperture, the main lobe size (the image obtained with a circular aperture is called an Airy pattern, of which diameter D is equal to 1.22 x a x

Fig. 13 shows a modification of the super-resolution light source according to the second embodiment shown in Fig. 12. In this modification, a substrate 510 made of, for example, SiO_2 is provided on the surface thereof with first, second and third phase areas 512a, 512b, 512c which produce operational effects similar to those produced by the first, second and third phase areas 502a, 502b, 502c above-mentioned. The substrate 510 is disposed opposite to the light emission face of a semiconductor laser 514.

In the optical pickup head devices and the super-resolution light source devices according to the first and second embodiments above-mentioned, the description has been made of the arrangement where two light sources comprising the second and third light sources are used as auxiliary light sources, but the number of the auxiliary light sources is not limited to two. Rows of faint auxiliary light sources comprising fourth and fifth light sources may be combined to enhance the superresolution effect and the side-lobe restraining effect.

Fig. 14 shows the principle of a holographic filter for superresolution which provides an equivalent of the superresolution light source device above-mentioned and which can be commonly used in the light pickup head devices according to the first and second embodiments of the present invention.

With the principal light source of the first light source 301 shown in Fig. 7 regarded as a reference light source and with the auxiliary light source rows of the second and third light sources 302A, 302B 303A, 303B in Fig. 7 regarded as object lights, an interference pattern is recorded on a photosensitive plane 330. Here, distances between the respective points are extremely small of 10^{-3} order (one thousandsth) as compared with the distance f_3 between the light source face 300 and the photosensitive face 330. Accordingly, there is obtained, on the photosensitive plane 330, an interference pattern of a kind of a lensless Fourier transform hologram. For example, an interference component of the points 301 and 302A with each other and an interference component of the points 301 and 302B with each other, appear in the form of a curve 340 as the intensity distribution $I(\zeta)$, and an interference component of the points 301 and 303A with each other and an inteference component of the points 301 and 303B with each other, appear in the form of a curve 342. This is considerably different from a conventional holography in that an interference pattern in mere several cycles is formed in a predetermined opening.

Figs. 15 to 17 show a method of actually producing a superresolution holographic filter according to the holography above-mentioned.

As shown in Fig. 15, a coherent beam emitted from a semiconductor laser light source 600 is focused on a pinhole 604 through a focusing lens 602 for spatial filtering, and is then incident upon a phase plate 606 having a predetermined phase structure, so that a hologram is formed on a hologram plane of a photosensitive medium 608 disposed at a position remote by a distance f_5 from the phase plate 606.

Fig. 16 (a) and (b) show an annular phase structure formed on the surface of the phase plate 606 serving as a superresolution filter. Fig. 16 (b) is a section view taken along the line XVI-XVI in Fig. 16 (a). The phase plate 606 is provided on the surface thereof with a center area 606a (phase Φ = 0) in the form of a circular convex formed at the center of the surface, a first phase area 606b (phase $\Phi = \pi$) in the form of an anannular concave formed outside of the center area 606a, a second phase area 606c (phase $\Phi = 0$) in the form of an annular convex formed outside of the first phase area 606b, a third phase area 606d (phase $\Phi = \pi$) in the form of an annular concave formed outside of the second phase area 606c, a fourth phase area 606e (phase $\Phi = 0$) in the form of an annular convex formed outside of the third phase area 606d, and an opaque area 606f in the form of a convex outside of the fourth phase area 606e. According to the operational principle discussed with reference to Fig. 12, a beam which penetrates the center area 606a of the phase plate 606, serves as the reference light mentioned earlier.

Fig. 17 (a) and (b) show an annular phase structure formed on the surface of a phase plate 610 serving as a superresolution filter as a modification of the phase plate 606. Fig. 17 (b) is a section view taken along the line XVII-XVII in Fig. 17 (a). The phase plate 610 is provided on the surface thereof with an inner annular concave groove 610a (the radius of the outer periphery: R_1) and an outer annular concave groove 610b. In the circular area inside of the inner concave groove 610a, an opaque area is formed except for a center area 610c (diameter: Δ) comprising a circular transparent part. Formed between the inner and outer concave grooves 610a, 610b is an annular area 610d comprising an annular transparent part. According to the operational principle discussed with reference to Fig. 14, a beam which transmits the center area 610c (phase $\Phi = 0$) of the phase plate 610, serves as the reference light mentioned earlier. The inner concave groove 610a forms the first phase area (phase $\Phi = \pi$), the annular area 610d (the radius of the inner periphery: R_2 forms a second phase area (phase $\Phi = 0$), and the outer concave groove 610b forms a third phase area (phase $\Phi = \pi$).

same. It is a matter of course that a superresolution filter can be formed on a collimate lens face in such a manner.

Claims

1. A superresolution scanning optical device comprising image forming means for forming the image of light from a coherent light source unit in the form of a fine spot on a conjugate face through an image forming optical system, and scanning means for scanning said fine spot formed on said conjugate face,

   said coherent light source unit having at least a first light source and a second light source presenting a phase reverse to that of said first light source,

   said first and second light sources having the relationship that the main lobe of the image of said second light source on said conjugate face is superposed on the lateral sides of the main lobe of the image of said first light source on said conjugate face.

2. A superresolution scanning optical device according to Claim 1, wherein:

   the coherent light source unit further includes a third light source presenting the same phase as that of the first light source; and

   said second and third light sources have the relationship that the main lobe of the image of said third light source on the conjugate face is superposed on the lateral sides of the main lobe of the image of said second light source on said conjugate face.

3. A superresolution light source device for optical device comprising at least first and second light sources which are coherent with each other and which are reverse in phase,

   said first light source being disposed on the optical axis of an image forming optical system or in the vicinity of said optical axis, and

   said second light source being disposed in the vicinity of said first light source.

4. A superresolution light source device for optical device according to Claim 3, wherein

   the second light source is smaller in output than the first light source.

5. A superresolution light source device for optical device according to Claim 3, further comprising at least a third light source which is coherent with the second light source and which has a phase reverse to that of said second light source,

   said third light source being located in the vicinity of and at the opposite side of said second light source with respect to said first light source.

6. A superresolution light source device for optical device according to Claim 5, wherein

   the second light source is smaller in output than the first light source, and

   the third light source is smaller in output than said second light source.

7. A superresolution light source device for optical device comprising a coherent light source for emitting a coherent beam, and a phase plate disposed in the vicinity of and opposite to a beam emitting part of said coherent light source for emitting a coherent beam,

   said phase plate having a first phase area for imparting a predetermined phase to a first area which is the center of a coherent beam emitted from said beam emitting part, and a second phase area for imparting a phase reverse to said predetermined phase to a second area outside of said first area of said coherent beam emitted from said beam emitting part.

8. A superresolution light source device for optical device according to Claim 7, wherein the phase plate is arranged such that an output of the second area of a coherent beam emitted from the beam emitting part is smaller than an output of the first area of said coherent beam

9. A superresolution light source device for optical device according to Claim 7, wherein the first phase area is circular and the second phase area is annular.

10. A superresolution light source device for optical device according to Claim 7, wherein the first phase area is rectangular and the second phase area is made in the form of a rectangular frame.

11. A superresolution light source device for optical device according to Claim 7, wherein the phase plate has a third phase area which imparts a phase reverse to that of the second phase area, to a third area outside of the second area of a coherent beam emitted from the beam emitting part.

12. A superresolution light source device for optical device according to Claim 11, wherein the phase plate is arranged such that an output of the third area of a coherent beam emitted from the beam emitting part is smaller than an out-

structure, a superresolution filter for optical device according to Claim 16.

21. A superresolution scanning optical device comprising a coherent light source, focusing means having a collimate lens for focusing a coherent beam emitted from said coherent light source on a recording surface of an optical disc, and control means for controlling the relative position of said focusing means with respect to said recording surface of said optical disc,

said collimate lens having, in a unitary structure, a superresolution filter for optical device according to Claim 17.

22. A superresolution scanning optical device comprising a coherent light source, focusing means having a collimate lens for focusing a coherent beam emitted from said coherent light source on a recording surface of an optical disc, and control means for controlling the relative position of said focusing means with respect to said recording surface of said optical disc,

said collimate lens having, in a unitary structure, a superresolution filter for optical device according to Claim 18.

23. A superresolution scanning optical device comprising a coherent light source, focusing means having an objective lens for focusing a coherent beam emitted from said coherent light source on a recording surface of an optical disc, and control means for controlling the relative position of said focusing means with respect to said recording surface of said optical disc,

said objective lens having, in a unitary structure, a superresolution filter for optical device according to Claim 15.

24. A superresolution scanning optical device comprising a coherent light source, focusing means having an objective lens for focusing a coherent beam emitted from said coherent light source on a recording surface of an optical disc, and control means for controlling the relative position of said focusing means with respect to said recording surface of said optical disc,

said objective lens having, in a unitary structure, a superresolution filter for optical device according to Claim 16.

25. A superresolution scanning optical device comprising a coherent light source, focusing means having an objective lens for focusing a coherent beam emitted from said coherent light source on a recording surface of an optical disc, and control means for controlling the relative position of said focusing means with respect to said recording surface of said optical disc,

said objective lens having, in a unitary structure, a superresolution filter for optical device according to Claim 17.

26. A superresolution scanning optical device comprising a coherent light source, focusing means having an objective lens for focusing a coherent beam emitted from said coherent light source on a recording surface of an optical disc, and control means for controlling the relative position of said focusing means with respect to said recording surface of said optical disc,

said objective lens having, in a unitary structure, a superresolution filter for optical device according to Claim 18.

27. A superresolution scanning optical device comprising a coherent light source and focusing means having a collimate lens, a polygon mirror and a focusing lens for focusing a coherent beam emitted from said coherent light source,

said collimate lens having, in a unitary structure, a superresolution filter for optical device according to Claim 15.

28. A superresolution scanning optical device comprising a coherent light source and focusing means having a collimate lens, a polygon mirror and a focusing lens for focusing a coherent beam emitted from said coherent light source,

said collimate lens having, in a unitary structure, a superresolution filter for optical device according to Claim 16.

29. A superresolution scanning optical device comprising a coherent light source and focusing means having a collimate lens, a polygon mirror and a focusing lens for focusing a coherent beam emitted from said coherent light source,

said collimate lens having, in a unitary structure, a superresolution filter for optical device according to Claim 17.

30. A superresolution scanning optical device comprising a coherent light source and focusing means having a collimate lens, a polygon mirror and a focusing lens for focusing a coherent beam emitted from said coherent light source,

said collimate lens having, in a unitary structure, a superresolution filter for optical device according to Claim 18.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 93 10 4561

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
P,X	EP-A-0 476 931 (CANON K. K.) * claims 3-5; figures *	1-14	G02B27/00 G02B27/58
A	US-A-4 699 465 (R.R.RICE ET AL.) * column 3, line 13 - line 26; figure 1 *	1-3,7	
A	APPLIED OPTICS vol. 29, no. 20, 10 July 1990, NEW YORK US pages 3046 - 3051 Y.YAMANAKA ET AL. 'High density recording by superresolution in an optical disk memory system' * abstract *	1,3, 20-26	
A	APPLIED OPTICS vol. 28, no. 4, 15 February 1989, NEW YORK US pages 687 - 693 ST.M.WATSON ET AL. 'Sidelobe reduction via multiaperture optical systems' * abstract * * page 692 *	1,3	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	EP-A-0 116 896 (HITACHI) * abstract; claim 9; figures 5,13 *	15-18	G02B G11B
A	EP-A-0 401 764 (PENCOM) * claim 11 *	15-26	
A	EP-A-0 310 711 (HITACHI ET AL.) * abstract; figures 6,7 *	20-34	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	23 JUNE 1993	FUCHS R.

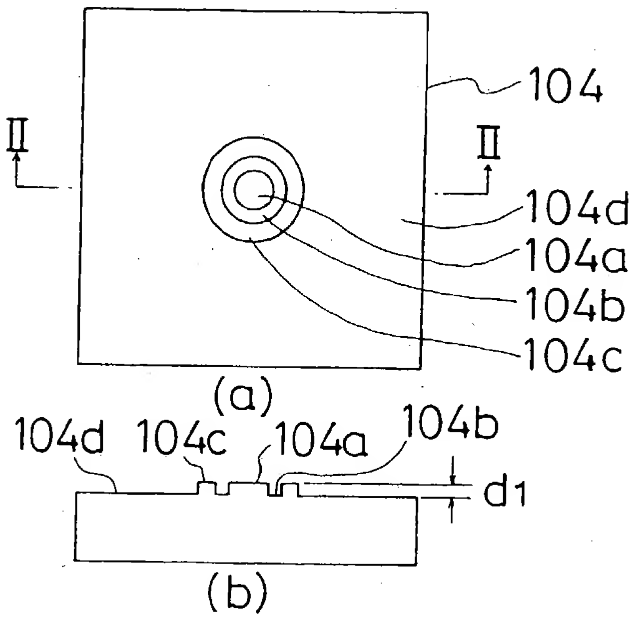
CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

Fig.2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II
II
104d
104a
104b
104c
(a)
104d
104c
104a
104b
d1
(b)

Fig.3

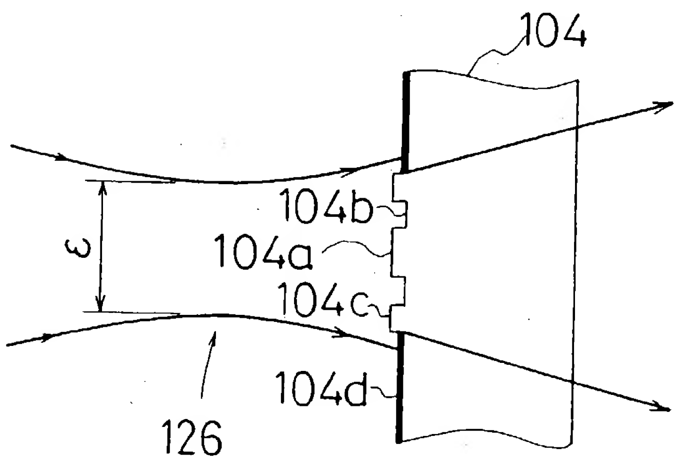
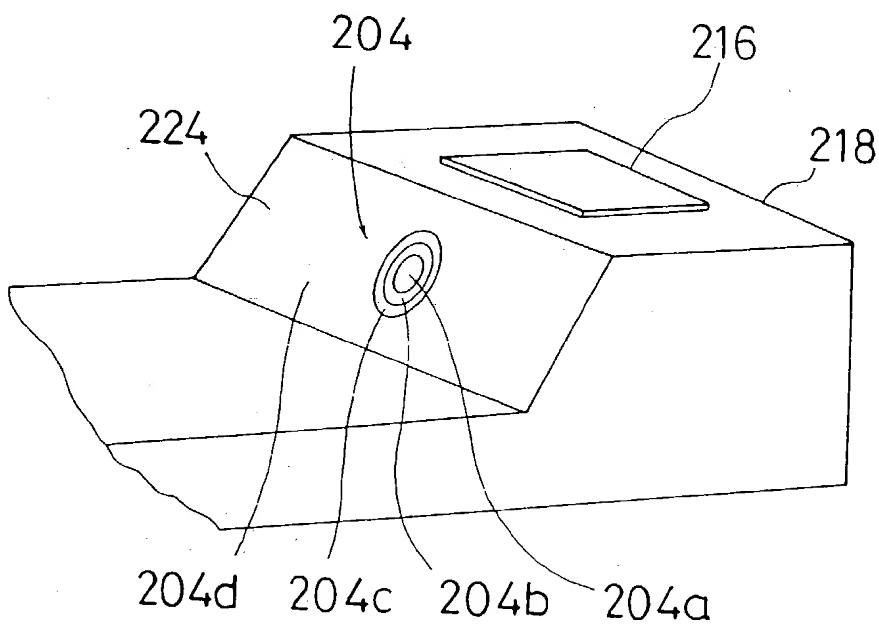
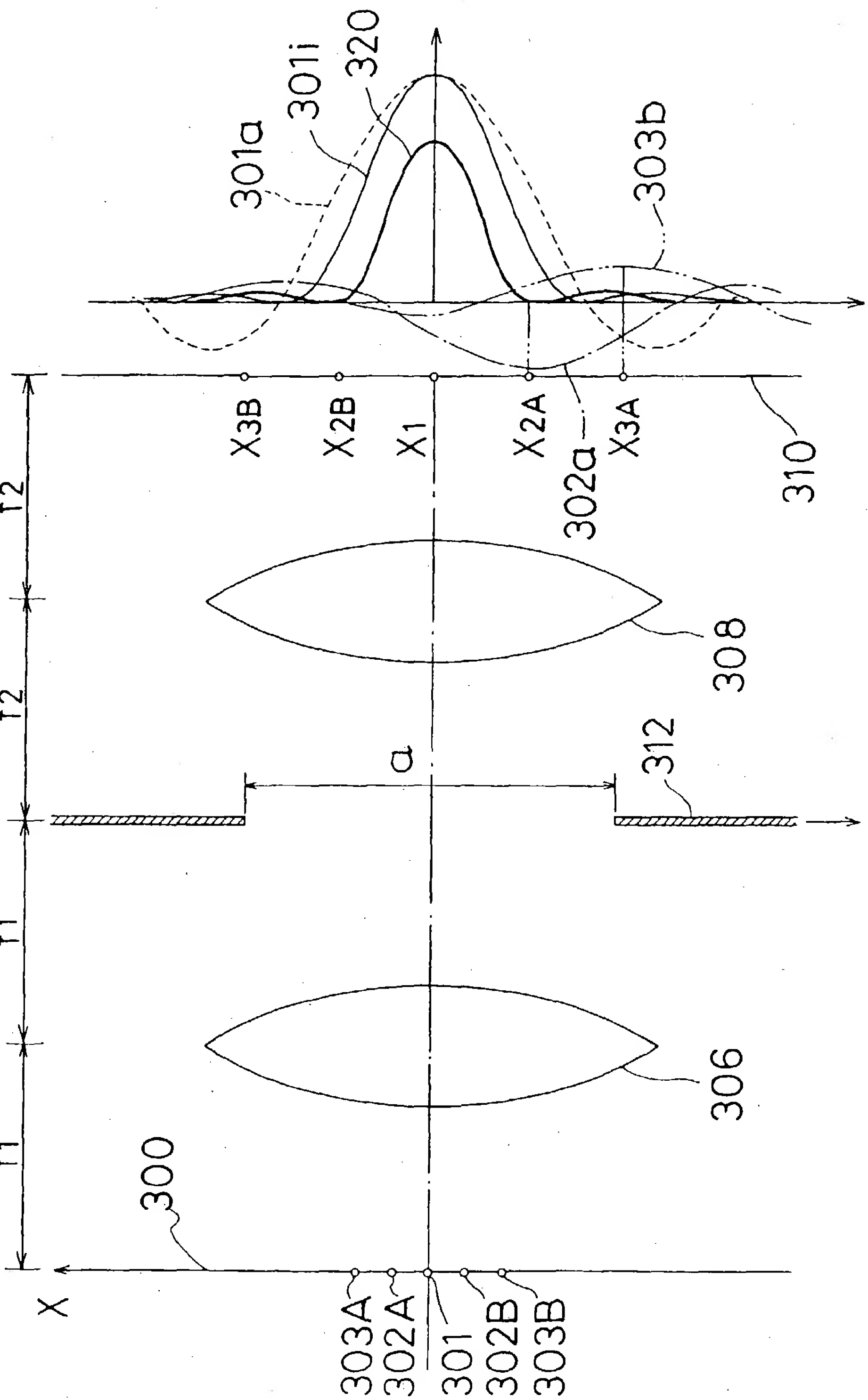

104
ω
104b
104a
104c
104d
126

Fig.5





f1
f1
f2
f2
a
X
300
301
302A
302B
303A
303B
306
308
310
312
X1
X2A
X2B
X3A
X3B
301a
301i
320
302a
303b

Fig. 7

Fig.9

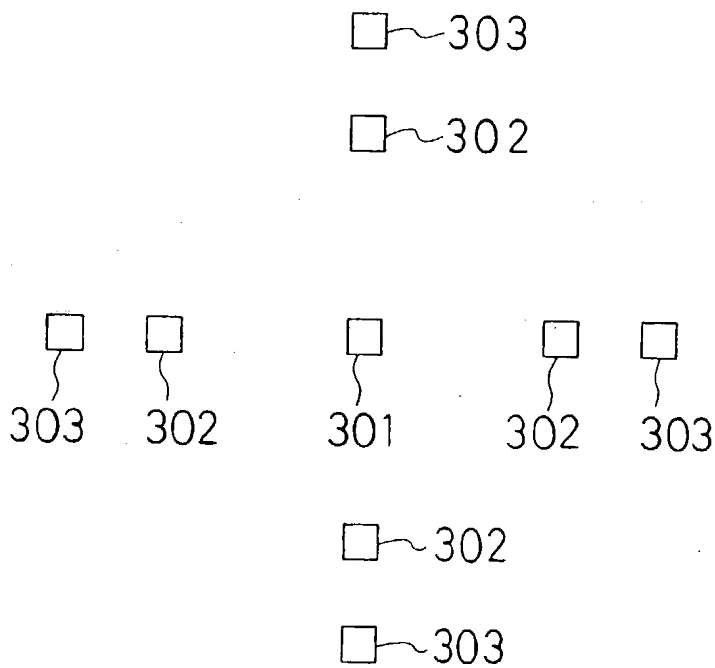


Fig.11

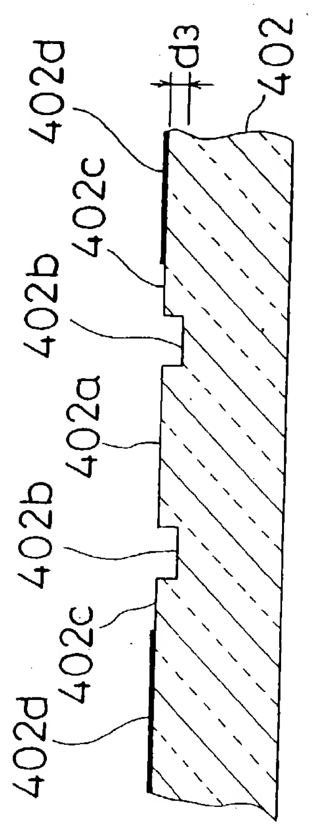


Fig.13

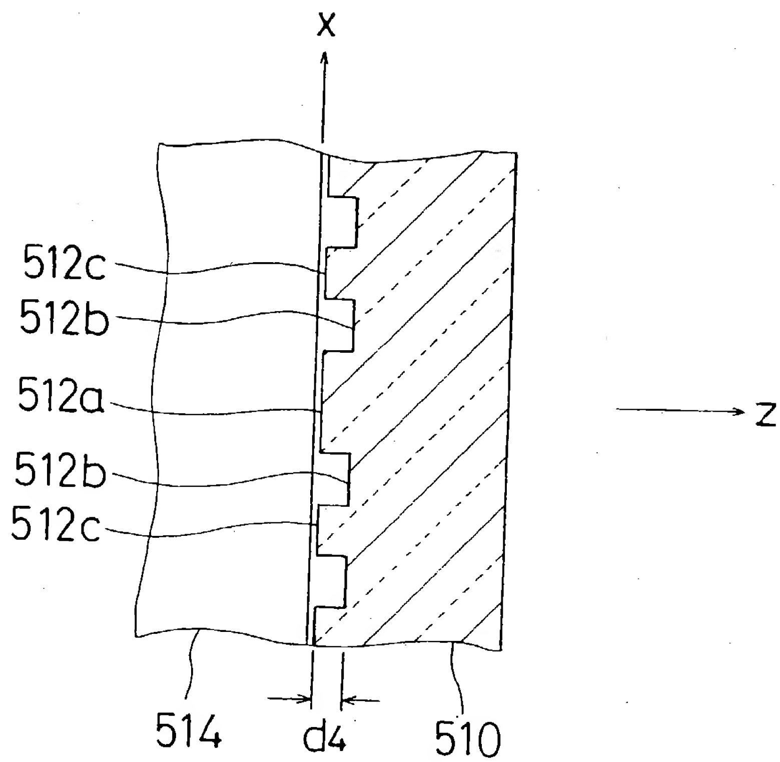


Fig.15

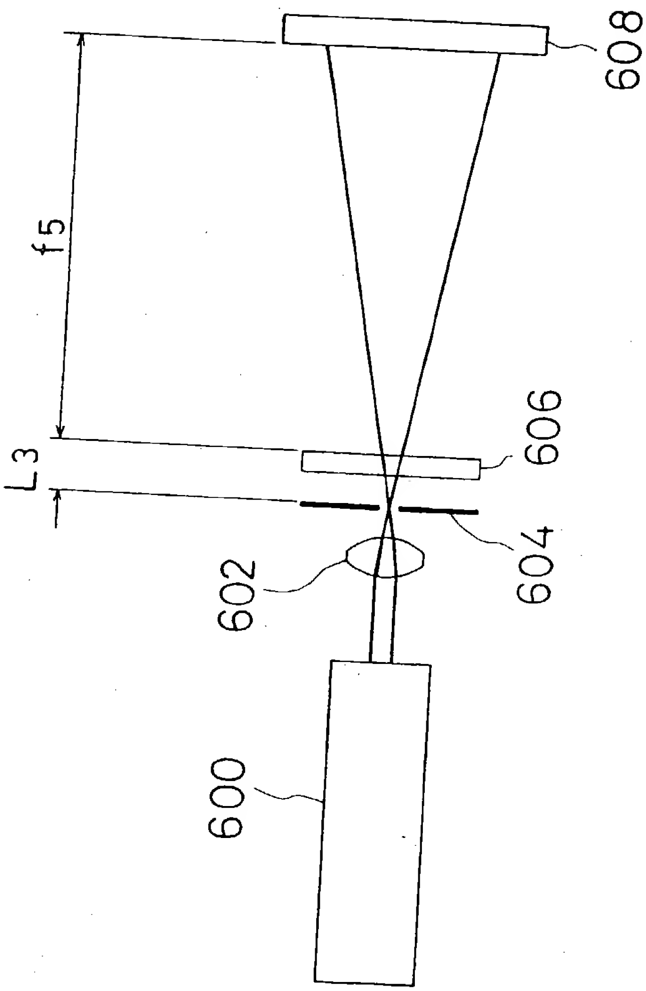


Fig.17

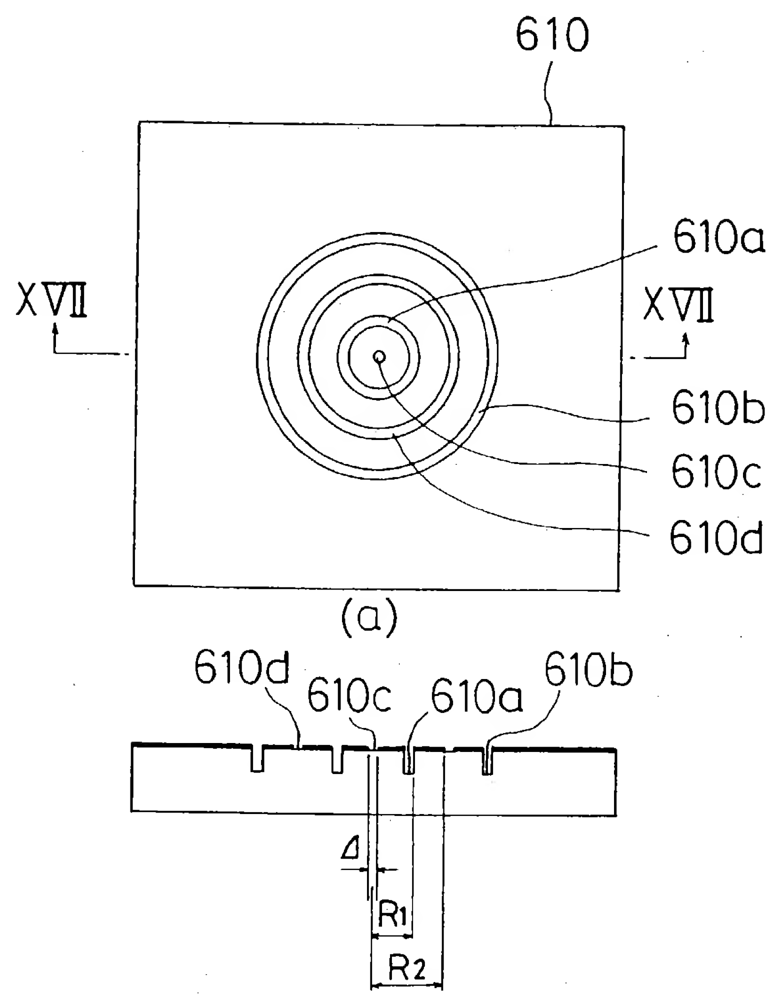


Fig.19
PRIOR ART